Historic, archived document

Do not assume content reflects current scientific knowledge, policies, or practices.

UNITED STATES DEPARTMENT OF AGRICULTURE
MISCELLANEOUS CIRCULAR NO. 100

WASHINGTON, D. C. APRIL, 1927

THE NATURAL REPLACEMENT OF BLIGHT-KILLED CHESTNUT

F-201+20

UNITED STATES DEPARTMENT OF AGRICULTURE

MISCELLANEOUS CIRCULAR NO. 100

WASHINGTON, D. C. APRIL, 1927

THE NATURAL REPLACEMENT OF BLIGHT-KILLED CHESTNUT

By C. F. Korstian, *Associate Silviculturist, Appalachian Forest Experiment Station*, and Paul W. Stickel, *Junior Forester, Northeastern Forest Experiment Station, Forest Service*

CONTENTS

	Page		Page
The spread of the blight dooms chestnut	1	Influence of chestnut loss on the growth of the forest—Continued.	
Salvage of the blight-killed timber	2	Height growth of reproduction	8
The importance of chestnut replacement	3	Stimulation of growth in basal area	10
Nature and extent of chestnut replacement	4	Cutting methods to promote replacement	10
In southern New England	6	Planting to replace chestnut	12
In northern New Jersey	7	Economic value of the replacement species	12
In Pennsylvania	7	Summary	13
Influence of chestnut loss on the growth of the forest	8	Literature cited	14

THE SPREAD OF THE BLIGHT DOOMS CHESTNUT

Failure of all effort to stop the spread of the chestnut blight (*Endothia parasitica*) has made apparent the approaching doom of chestnut (*Castanea dentata*) as a timber tree in eastern United States. As a result foresters and landowners have been forced to turn their attention to salvage of the chestnut timber already in existence and to its replacement in the forest by other valuable species of timber trees.

Following its discovery in Bronx Park, New York City, in 1904, the blight spread rapidly northeastward, westward, and southwestward. In 1907 it was already locally epidemic, and by 1910 it had swept across most of New Jersey and into southeastern Pennsylvania, in which region about 80 per cent of the chestnut was infected. By 1915 much of the chestnut in southern Connecticut, New Jersey, southeastern New York, Pennsylvania, and northeastern Maryland was either dying or heavily infected. By 1920 the 80 per cent infection zone had extended to southwestern Pennsylvania, western Maryland, northeastern West Virginia, and south along the Blue Ridge Mountains to central Virginia. At the present time (1926) nearly all of the mature chestnut in southern New England, southeastern New York, New Jersey, eastern and central Pennsylvania and Mary-

land, and northern Virginia has been killed. Local infections have been reported throughout the mountains of West Virginia, western North Carolina and Virginia, eastern Tennessee, northern Georgia, and northwestern South Carolina.

State and Federal agencies have conducted many studies designed to find some means to stop the ravages of the blight. The rate of spread in the southern Appalachian region is being studied by the Office of Forest Pathology, Bureau of Plant Industry, United States Department of Agriculture. The department is also investigating the possibility of obtaining resistant strains of species of chestnut, either of natural occurrence or through propagation (*4*).[1]

From 1911 to 1913, Pennsylvania made a determined effort to check the westward spread of the blight, and to stamp it out in the western part of that State. Advance spot infections were located by a state-wide scouting organization and the diseased material was destroyed. An elaborate series of studies included experiments on the germination, growth, dissemination, and control of the chestnut blight fungus (*1*, *13*, *18*). Treatments with fungicides and injections of various chemicals into the chestnut trees were tested. Though information of scientific value was obtained, no cure for the blight and no means of rendering trees immune was discovered. Further, the many experiments resulted in no effective means of preventing the spread of the blight from tree to tree. The only method of control which was found at all practicable was the simple yet very costly one of cutting the diseased trees, peeling the infected logs and stumps, and burning the brush and bark over the stumps (*9*).

The westward spread of the blight across Pennsylvania was retarded but not stopped by this system of scouting and destruction of advance infections. About half a million dollars was spent in Pennsylvania, chiefly through its chestnut-tree blight commission, in studies and control measures, mainly the latter.

Within another decade most of the mature chestnut will have been killed over large areas in the southern Appalachian region (*6*, *10*). The long growing season and high humidity of the South are very favorable to the growth and spread of the blight. Birds in their southward migration each year along the mountain ranges doubtless aid materially in disseminating the disease. It is also carried for many miles on shipments of chestnut lumber, on nursery stock, by insects, and by the wind itself. Though in certain cases of isolated spot infections far in advance of the zone of heavy infection, it may be advisable to eradicate the diseased trees, since the removal of advance infections materially retards the progress of the general zone of heavy infection, the native chestnut is doomed to extinction as a commercial timber tree in eastern United States. Forest pathologists and foresters are unanimously of the opinion that at this time there is no practical method of stopping the spread of the blight (*5*).

SALVAGE OF THE BLIGHT-KILLED TIMBER

When it became evident that the blight could not be stopped, attention was generally centered upon the salvage of the chestnut.

[1] Italic numbers in parentheses refer to "Literature cited," p. 14.

Over the readily accessible parts of the North, as in Connecticut, most of the chestnut has already been utilized. In the more remote localities salvage becomes a difficult problem.

Sound chestnut logs, poles, ties, and other products obtained from trees infected with or killed by the blight have sometimes been rejected because of the fear that the disease had affected the quality of the timber. This fear, however, has been shown to be baseless (*12*). Strength tests conducted by the Forest Products Laboratory indicate that sound wood from blight-killed trees is fully as strong as wood from healthy trees. However, in trees killed from any cause, including blight, checking is likely to occur with the drying of the wood. Checking in small trees will start the second year after the blight has completed its work, and in all trees is rapid after the fifth year. When checking progresses sufficiently to become serious the value of the timber is greatly lessened for purposes other than fuel or extract wood.

Sap rot appears as small spots on the trunk, generally within two years after the trees have died. The rot spreads until by the fourth year practically all the sapwood has rotted. This, however, does not preclude using the heartwood for such products as ties, posts, or cordwood, since the removal of the narrow band of rotted sapwood is not difficult. However, by about the fifth or sixth year the bark has usually fallen from the trunk, and the rotted sapwood, which may be full of insect galleries, dries out and begins to peel off. The heartwood is still hard and sound, but the small trees are often so badly checked as to be unmerchantable except as cordwood. On the other hand, trees dead for as long as 20 years have been felled and sawed into acceptable lumber.

It has been suggested that "ringing" or girdling may retard the rotting of the sapwood (*10*). If the trees are girdled while the leaves are still on them, the trunks will dry out very rapidly and the bark will loosen sooner than after death by blight. This may be a practical means of preventing excessive decay in large, sound trees which contain much clear material.

Owners of chestnut timber should plan ahead for its utilization in order to avoid a possible loss due to a glut of the market when all the owners in a locality are desperately trying to get rid of their blight-killed material. If the stand is growing rapidly and increasing in value, it may not be advisable to cut the timber until it becomes infected; but in all cases where the area is too large to cut over in a short time, the salvage operations should be undertaken before the blight becomes prevalent. Owners of extensive tracts of timber running heavily to chestnut should, therefore, sell their chestnut as rapidly as suitable markets can be found for it.

THE IMPORTANCE OF CHESTNUT REPLACEMENT

The composition of the hardwood forests of southern New England, New Jersey, and central and southern Pennsylvania has been radically changed by the death of the chestnut. Chestnut formed almost half of the hardwood forests of this region prior to its destruction by the blight; on small areas it often formed 90 per cent of the total wood volume. No other tree in the entire region furnished such a variety of valuable wood products. In addition to its

value for lumber and firewood, its durability and size adapted it particularly for telegraph and telephone poles, piles, and railroad and mine timbers. Its rapid growth, abundance, and prodigious sprouting capacity, coupled with its intrinsic value, made it the most promising of the northeastern forest trees. The total loss of such a tree naturally introduces serious problems in the future management of the forests, both in the North, where the chestnut is already dead, and in the southern Appalachians where, although still furnishing abundant and valuable forest products, it is doomed to extinction.

The question of what is replacing chestnut is of great importance to the forester and the timberland owner, and to others interested in the welfare of our forests. Knowledge of what is happening on blight-killed chestnut areas is necessary in order to appraise the future rate of growth of the changed forests, the quality and value of their products, and the time needed to restore the lands to their full productive capacity with species other than chestnut.

As a first step toward supplying such information studies have been made of the effects of the chestnut blight on the forest, the number and kinds of trees that naturally replace blight-killed chestnut, and the means that might be used to replace the chestnut with desirable species.

NATURE AND EXTENT OF CHESTNUT REPLACEMENT

A preliminary field study of the character and extent of natural reproduction following the killing of the chestnut by the blight was undertaken by the Forest Service in 1920. The Natural Bridge and the Shenandoah National Forests in Virginia, and the older infected areas in Maryland, eastern Pennsylvania and northern New Jersey were examined.

This study showed that there were in general sufficient young trees of desirable species already growing under the chestnut to restock the stands.[2] Although this advance reproduction might not be present in the larger sizes so that future merchantable stands would in some cases be delayed, there would be no vacant areas of any appreciable extent after the chestnut had died. On the more unfavorable sites, however, advance reproduction was inadequate. This, coupled with dense underbrush, made it possible that the regeneration of the desirable species might be delayed a long time.

No particular method of cutting was recommended by the investigator other than that which was necessary to salvage the timber. But in stands with dense underbrush or with a large percentage of unmerchantable trees, in which commercial logging methods were considered inadequate, improvement cuttings were recommended.

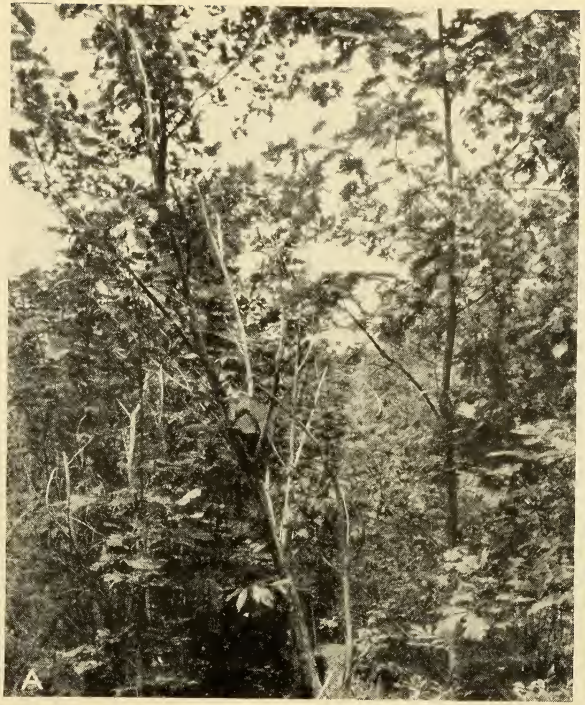
In 1924 the writers[3] made a study of blight-depleted stands in the earlier infected regions of southern New England, northern New Jersey, and Pennsylvania. The objects of this study were to determine the progress of the natural replacement of the chestnut by other species of trees; to forecast as nearly as

[2] HODSON, E. R. PRELIMINARY REPORT ON THE SILVICULTURE OF REPLACING THE CHESTNUT ON BLIGHT-KILLED AREAS. [Unpublished manuscript.]

[3] In this study the writers received the effective cooperation of R. C. Hawley, of the School of Forestry, Yale University; W. O. Filley, forester, Connecticut Agricultural Experiment Station; W. M. Baker, associate State forester of New Jersey; and J. S. Illick, chief of information, Pennsylvania Department of Forests and Waters.

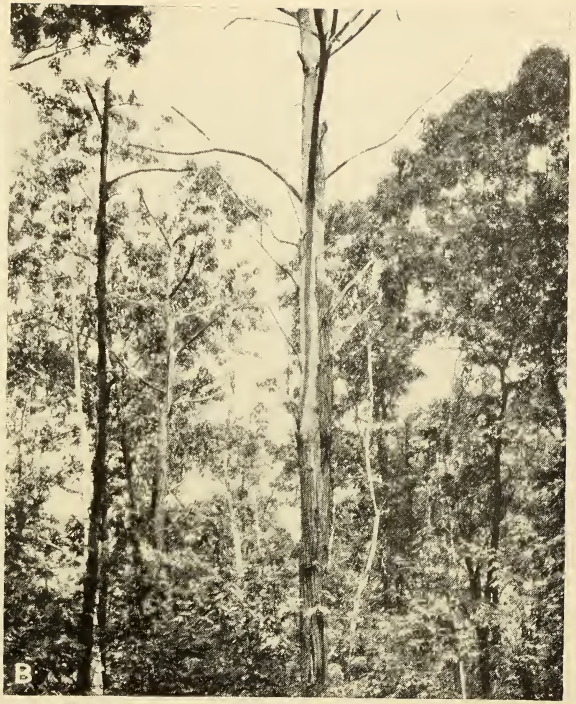
F-15599

A stand of chestnut, oak, and maple in which there is ample advance growth, chiefly of maple, oak, and white pine, to fill in the blanks left by the death of chestnut. (Worcester County, Mass.)



F-187631

A.—A young stand of hardwoods following clear cutting about 15 years ago. The first three generations of chestnut sprouts have been killed by the blight and the overtopped fourth generation is heavily infected. The opening left by the chestnut has been completely filled by red oak, hickory, and yellow poplar, the crowns of which are interlaced. (Southern Connecticut)



F-187636

B.—A blank in a stand of hardwoods left by the death of the chestnut. The surrounding oaks are filling it in by the extension of their crowns. The crown cover will soon be completely closed. (Southern Connecticut)

possible the impending changes in the composition of the stand; to compare the growth rates of the important timber trees replacing the chestnut; and to ascertain whether and under what conditions special treatment of the stand is justified to promote replacement with especially desirable species. Facts obtained in the North in regard to these points can doubtless be applied with advantage in the South, even in advance of the death of the chestnut.

The 1924 study was similar to that made in 1920, but was more intensive, was extended so as to cover in a representative way the different-aged stands on the important chestnut sites, and, where possible, was carried back to the beginning of the blight infection. In southern Connecticut detailed investigations of reproduction and growth were conducted by means of sample areas, on some of which records are available as far back as 1904, the year the blight was discovered. For these areas, each of which covered from one-tenth to one-fourth acre, all essential details, such as the species, size, and position of each tree in the forest canopy, were recorded. Investigation was also made of the changes taking place in other typical stands, selected with reference to forest type, site, and stand conditions.

In order to obtain detailed information about the kind, origin, and amount of the small reproduction coming in on the areas formerly occupied by the chestnut, a number of areas 1 square rod in size were so laid out that the chestnut stumps or dead chestnut trees occurred near the center of each. All forest tree reproduction and the larger shrubs on these areas were recorded by species and size and a record was made of their origin, whether seedling or sprout.

The accelerated growth of neighboring trees of other species released by the death of the chestnut was studied in typical stands.

Since the detailed results of the study will be published elsewhere, only the more important results and conclusions will be given in this circular.

The 1924 study confirmed the conclusion reached in the study of 1920 that there is generally sufficient advance growth of valuable species to restock the stand. (Pl. 1.) It also brought out the fact that the blight-killed chestnut has been very largely replaced by oak. On areas originally occupied by chestnut, oak reproduction was found very generally, together with reproduction of such other valuable species as hickory, white ash, yellow poplar, sugar maple, and sweet birch. (Pl. 2, A.)

Practically all of the stands examined were analyzed to determine the extent to which the replacing species are silviculturally desirable or economically valuable. These species were grouped as follows:

Class 1.—Desirable species: Red oak (*Quercus borealis maxima*), white oak (*Q. alba*), black oak (*Q. velutina*), chestnut oak (*Q. montana* Willd.), hickory (*Hicoria* spp.), white ash (*Fraxinus americana*), sugar maple (*Acer saccharum*), sweet birch (*Betula lenta*), black cherry (*Prunus serotina*), yellow poplar (*Liriodendron tulipifera*), basswood (*Tilia glabra* Vent.), northern white pine (*Pinus strobus*), and pitch pine[4] (*P. rigida*).

[4] Pennsylvania and New Jersey pitch pine is a class 1 species, whereas in New England pitch pine is very seldom associated with chestnut.

Class 2.—Less desirable species: Scarlet oak (*Quercus coccinea*), red maple (*Acer rubrum*), beech (*Fagus grandifolia* Ehrh.), black gum (*Nyssa sylvatica*), aspen (*Populus tremuloides*), largetooth aspen (*P. grandidentata*), and eastern cottonwood (*P. deltoides*).

Class 3.—Undesirable species:[5] Dogwood (*Cornus* spp.), gray birch (*Betula populifolia*), bear or scrub oak (*Quercus ilicifolia* Wang.), sassafras (*Sassafras variifolium* (Salisb.) Kuntze), blue beech (*Carpinus caroliniana*), hop-hornbeam (*Ostrya virginiana*), witch-hazel (*Hamamelis virginiana*), and serviceberry (*Amelanchier canadensis*).

IN SOUTHERN NEW ENGLAND

On the representative areas studied in southern New England the chestnut has been naturally replaced by other species, largely valuable oaks, and the blanks left by the removal of the chestnut are filled by a much larger number of seedlings and sprouts than can possibly survive. Red oak and chestnut oak have increased both in number of trees and volume of wood. And in addition to this new growth of young trees, the surrounding oaks and other hardwoods are filling in the gaps in the forest canopy by the extension of their crowns. (Pl. 2, B.)

A decrease occurred in the total number of large trees of all species on most of the areas studied. This was due not only to the loss of the chestnut but also to the removal of some of the less vigorous and less desirable individuals of the oaks and other species when the chestnut was salvaged. The reduction in forest growing stock, or capital, is partly offset by the increased growth of the oaks, which will be considered under another heading.

Practically half of the new reproduction is of desirable tree species and about 65 per cent of these are species which at present have an economic value. Furthermore, on over two-thirds of the entire area studied the tallest saplings are class 1 species. About 65 per cent of the class 1 reproduction is of seedling origin.

The goodly proportion of red oak and white ash in the replacement reproduction on many areas is especially noteworthy. The importance of red oak, because of its rapid growth in height and diameter and the excellent character of its timber, has long been recognized. There is little doubt that both species will increase rapidly in economic importance now that their formidable rival—the chestnut—has been destroyed.

The blight-killed chestnut stands of southern New England are restocking naturally to silviculturally desirable and economically valuable species. These species are much in excess of the undesirable shrub-weed species. If, as is occasionally true, the more desirable species are outnumbered by the undesirable ones, nevertheless, the desirable species, having the more rapid growth rate, will soon overtop the inferior species and partially or completely suppress them. It is also encouraging to note that in those cases where the total number of desirable species may not equal that of the undesirable ones, the desirable species in the overstory are already in excess of the others. Moreover, the tallest saplings in the gaps left by the

[5] Various other shrubs large enough to appear in the records were also included in this class.

death of the chestnut are mostly of desirable species, such as the oaks, hickory, and ash, rather than of shrub or weed species, such as dogwood, sassafras, blue beech, and gray birch.

IN NORTHERN NEW JERSEY

The studies of the natural replacement of chestnut in northern New Jersey showed that there is ample forest tree reproduction to fill the gaps, although the percentage of class 1 species is much lower than in southern New England. As less than half of the reproduction of species other than chestnut falls in classes 1 and 2, modification of the composition of the stand is desirable. It is encouraging, however, to note that the tallest saplings on slightly over 80 per cent of the area studied on the Stokes State forest are either class 1 or class 2 species, although the percentage of class 1 is small.

The stands studied in New Jersey were characterized by the presence of white pine and pitch pine, and contained a higher percentage of the undesirable species in the overstory and a denser understory and undergrowth than those studied in Connecticut. Although the chestnut is being replaced naturally for the most part by tree species, the presence of a relatively high proportion of undesirable species introduces important problems in connection with subsequent thinnings and improvement cuttings. These will be considered under another heading.

IN PENNSYLVANIA

In northeastern Pennsylvania the stands were found to have restocked mostly to desirable species, and almost as rapidly as the chestnut disappeared.

Observations made in Franklin County are of special interest. On slopes where the chestnut had occupied 40 per cent or more of the original stand, seedlings and sprouts of other species varied from 1,000 to 1,500 per acre. Of these, chestnut oak comprised 60 per cent, black oak 35 per cent, and white oak 4 per cent. Scattered red and scarlet oaks, white and pitch pines, and black locust (*Robinia pseudo-acacia*) made up the remainder. Here the oaks, which in the original stand were second in number to the chestnut, have insured adequately stocked stands of second growth. (Pl. 3.)

During the height of the epidemic in Pennsylvania, an opinion was prevalent that the space left by the death of the chestnut, aggregating an enormous area, would remain for a long time unstocked, or at most poorly stocked with undesirable species. Observations in localities where the blight has passed its final stage have shown the incorrectness of this opinion. Natural replacement was found to be more complete and better in quality than was anticipated, and was also steadily improving in quality.

The replacement will be more complete and more satisfactory in moist situations, however, than upon the drier slopes, for blanks on the moist sites will be relatively less extensive and the associated species, such as yellow poplar, white ash, red oak, white pine, red maple, and white oak, more desirable. Upon the drier slopes the blanks will be more extensive and the associated species are less desirable.

Chestnut oak, pitch pine, and black locust are also among the satisfactory species which are largely replacing the chestnut in Pennsylvania. Black oak, pignut hickory (*Hicoria glabra*), sweet birch, mountain pine (*Pinus pungens*), and Virginia pine (*P. virginiana*) are others which are helping to fill the gaps and are not to be despised (*8*).

INFLUENCE OF CHESTNUT LOSS ON THE GROWTH OF THE FOREST

It is evident that there will be a loss in growth of the forest, particularly during the first decade of the life of the replacing crop, because of the slower growth of the oak seedlings than of the chestnut sprouts. The young stands established following the elimination of the chestnut have a much higher percentage of reproduction of seedling origin. It is probable that this difference in rate of growth will still be evident in the stand after it has passed the juvenile stage.

For southern Pennsylvania Ziegler (*20*), as a result of studies on the Mont Alto State forest, concludes that chestnut was capable of producing, in pure stands, a cord to the acre each year, and that white oak and chestnut oak will produce only 30 to 40 per cent as much, and scarlet and red oaks 50 to 60 per cent. He maintains, therefore, that replacing chestnut with oaks would decrease the production of this forest over 50 per cent, as chestnut oak would be the most abundant replacement species. He contends that the increased value of oak over chestnut will be obtained only in the larger sizes and longer rotations, and that this will be more than offset by the failure to secure the profitable returns from early oak thinnings that were possible in the chestnut. No mention is made of the probable acceleration in growth rate of the oaks by the death of the chestnut and the attainment of positions in the dominant crown cover by a much higher percentage of oak than when the chestnut was the leading species in the stand. Nor does he take into account the fact that the new mixed stands may be in many ways more profitable than the pure stands of chestnut replaced (*17*, p. 74–76). The effects of the blight have made it manifest that they are less susceptible to injury by fungi.

In the present study it has been impossible to throw much light on the problem of the decrease in growth rate beyond the juvenile stage. It is possible, however, to consider from existing information and from that obtained in this study (1) the comparative rates of height growth of the chestnut and the young oak sprouts on reproducing areas, and (2) the stimulation of growth in cross-sectional or basal area following the death of the chestnut.

HEIGHT GROWTH OF REPRODUCTION

The large reserve energy stored in roots as compared with seeds gives sprouts which originate from stump or root collar a more rapid height growth than seedlings. Sprouts elongate rapidly from the start, attain maximum growth within the first decade, and exhaust themselves earlier than the slower starting but more persistent seedlings. Chestnut sprouts often reach a height of 8 feet the first year, whereas seedlings of the same age seldom attain a height of

A young stand of chestnut poles which has been killed by the blight. Most of the trees bearing living foliage are chestnut oak. Here the loss in trees not yet merchantable was augmented by replacement with slower-growing species. (Chester County, Pa.)

F-22311

A stand of chestnut sprouts salvaged for railroad ties when its destruction by the blight became evident. The extraordinary sprouting capacity of the chestnut is shown by the sprout clump in the foreground

even 1 foot (*21*). This rapid early growth and the prodigious sprouting capacity of chestnut are doubtless chiefly responsible for the abundance of chestnut and its characteristic predominance where the forest has been repeatedly and heavily cut in the past (pl. 4). The second-growth stands of chestnut are almost wholly of sprout origin, and this is true also of many stands of second-growth oak and other hardwoods in the Northeast.

Since the blight has altered the status of chestnut from a very desirable to an undesirable component of future stands, its prolific development of rapidly growing sprouts has become a menace. In blight-killed stands the live chestnut sprouts seldom attain a diameter of more than an inch before they, too, succumb. The third and fourth generations of sprouts were being killed by the blight at the time the field studies were made in southern New England. Two or three sprout generations may still be expected on the clear-cut areas and on those on which the chestnut was salvaged before it died. Many of the clumps of chestnut which were not cut before the trees died have already ceased to sprout.

In a study made by Mattoon (*11*) on the Maltby tract while the chestnut was still in its prime he found that the chestnut sprouts on a second-quality site averaged 5.7 feet tall at the end of the first year, and 8.3 feet tall at the close of the second year, while the heights of the red oak sprouts averaged only 66 per cent of those of the chestnut the first year and 64.5 per cent the second year. The rates of height growth of red maple, ash, red oak, and chestnut oak sprouts are compared with that of chestnut in Table 1. The figures for the last group of species are based upon comparatively few measurements of stands on first-quality sites, and therefore may not be average for the Northeast.

The oak sprouts show a pronounced retardation in their growth rate the second year, whereas the maple and ash preserve a relatively rapid height growth.

TABLE 1.—*Actual height-growth of chestnut sprouts and comparative height-growth of sprout reproduction during two seasons*

ACTUAL GROWTH

Species	First year	Second year	Both years
	Feet	*Feet*	*Feet*
Chestnut sprouts	6.1	3.4	9.5

COMPARATIVE GROWTH

	Per cent	*Per cent*	*Per cent*
Chestnut sprouts	100	100	100
Red maple sprouts	73	83	77
Ash sprouts	62	69	65
Red oak sprouts	69	52	63
Chestnut oak sprouts	59	40	52

As much of the reproduction now filling the blanks left by the chestnut is advance growth, it was possible in the present study to obtain only a few records of the comparative height growth of the associated species which had sprouted since the death of the chestnut.

Those for red oak agree in the main with the measurements recorded by Mattoon (*11*). They indicate, furthermore, that a satisfactory growth rate is sustained through the first decade of the life of the sprouts. Sprouts of black oak, red maple, scarlet oak, white oak, and hickory sustained their growth almost as well during their first decade.

STIMULATION OF GROWTH IN BASAL AREA

While the larger openings in the forest cover are, for the most part, being filled by seedlings and sprouts of valuable species, the smaller openings are being filled by the extension of the crowns of adjacent trees, particularly oaks.

A special study was made on the Maltby tract to determine for the dominant stand the accelerated growth of oak trees which gained in exposure to light following the death or removal of the chestnut. As the chestnut had been dead for an average of 10 years, the rates of growth for the last two decades were compared. Records were taken on a total of 134 trees, distributed as uniformly as possible within the following species and diameter classes: Chestnut oak and white oak, 7 to 12 inches; black oak and scarlet oak, 6 to 14 inches; and red oak, 7 to 20 inches. These trees were found to show an average acceleration in their rate of growth in cross-sectional area at breast height ranging from 26 per cent in white oak to 63 per cent in red oak. Chestnut oak showed an average increase of 48.2 per cent, and black oak and scarlet oak showed a gain of 38.2 per cent over the rate of growth during the decade prior to the death of the chestnut. The percentage of increase tended to be uniform in the different diameter classes, although it showed a moderate decline in the larger classes.

The increase in basal area of the stem at breast height may be considered as an indication of the possible increase in volume growth. It is realized, however, that an increase in diameter at breast height does not necessarily signify a uniform increase throughout the entire length of the stem. This increased growth rate will doubtless continue until the crowns close together sufficiently to crowd each other, when the rate will again begin to decline, continuing to fall off until the stand is opened again through cutting or through the death of some of the dominant trees.

CUTTING METHODS TO PROMOTE REPLACEMENT

Within certain limits natural replacement can be controlled and promoted by regulating the method of cutting. The most serious limitation is in most instances a restricted market which can not absorb all the material that should, in the interests of the best forestry practice, be cut at any given time, and which makes it impossible, therefore, to eliminate the young growth of undesirable species over large areas (*3*). It is quite feasible, however, and often very desirable to control the young growth of undesirable species on small areas. Both the 1920 and the 1924 studies indicate that in stands running heavily to chestnut and in which desirable species are not abundant heavy cuttings approaching clear cutting are desirable in order to secure reproduction of some of the more desirable species which are also light-demanding.

The benefit to the remaining trees of other species from the removal of competition for moisture, light, and crown space has already been mentioned. In many instances the salvaging of the dead chestnut in the Northeast has been accompanied by an improvement cutting to remove those trees which are undesirable from the standpoint of the growth and future development of the forest. Even where the blanks left by the chestnut are very large, the removal of these undesirable trees leaves a nucleus of vigorous trees to reseed the area. These trees will themselves develop so well that further minor cutting may be possible within 10 or 15 years. Also, the inclusion of the products from the less desirable material in the stand has often made it possible for the owner to dispose of his chestnut more readily.

In hardwood stands which have reached merchantable size for cordwood or other small-sized products, usually between 30 and 40 years old, thinnings can be made to advantage. In stands running heavily to chestnut, cuttings have taken more the nature of salvage of the chestnut. Such cuttings for salvage, combined with improvement cuttings in the remaining stand, may remove as much as 10 to 15 cords per acre. Stands thus treated may be left so open as to require little or no further thinning. Reproduction following such cuttings consists of both sprouts and seedlings, but usually with an increase in the amount of seedling reproduction.

Even if a stand is clear cut without previous thinning, good regeneration will follow, although with a higher percentage of sprouts. When a mature stand over 70 years old is cut clear, the sprout reproduction is often incomplete because of the failure of some of the stumps to sprout. This would suggest a preliminary reproduction cutting about 10 years before the final clear cutting. Such a reproduction cutting would take the form of a heavy thinning, removing, in addition to the chestnut, about one-third or one-half the volume of the stand, including some of the larger trees less likely to sprout and as many of the less desirable species as can be marketed. This would have the effect of encouraging seed reproduction of the heavy-seeded hardwoods, particularly the oaks. At the same time seedling regeneration would be adequately provided for by leaving good seed trees of the more desirable species. The resulting stand would be composed of trees of both seedling and sprout origin—an aim of good silvicultural practice.

Some of the most successful cases of natural replacement have been those following cuttings in which the removal of the chestnut was deferred until it had become heavily infected, or until a thrifty stand of young growth of desirable species, established following a reproduction cutting, had attained sufficient height to maintain itself successfully against the rapid-growing chestnut sprouts. If the removal of the chestnut is thus deferred, fewer and less vigorous chestnut sprouts are produced, and seedlings of desirable species have a better chance to overtop them when they do appear. However, the removal of the chestnut should not be deferred for more than five years after death, lest pronounced deterioration render the products unmarketable. This would apply particularly to the relatively inaccessible areas outside of the Northeast, where the chestnut has not yet succumbed to the blight.

PLANTING TO REPLACE CHESTNUT

As the northern chestnut began to die over extensive areas it was natural for foresters and others to recommend the planting of conifers, either before or after clearing of the area, as the best and only apparent means of replacing the blight-killed chestnut (*2*, *14*, *15*, *16*, *19*). Different species of pine, larch (Larix), and spruce (Picea) have been tried with varying success. That the conversion from hardwoods to conifers can be accomplished has been demonstrated, particularly by plantations of Norway pine (*Pinus resinosa*), Scotch pine (*P. silvestris*), and white pine. In the majority of these cases, experience to date indicates the need for a considerable amount of follow-up work in cutting out the hardwood sprouts to free the softwood plantations. Two or three cleanings or liberation cuttings at intervals of a few years will doubtless be required on much of the hardwood land.

In the North there are numerous instances in which hardwoods have grown up in softwood plantations and overtopped the planted trees, making liberation cuttings necessary to save the softwoods. When several such cuttings are necessary the cost is pyramided. Whether it is better financially to continue to grow hardwoods or to transform the present hardwood stands to conifers is still an open question (*7*). It must be recalled that the areas formerly occupied by the chestnut are potentially hardwood lands, and that it will not be possible, in most instances, to reproduce the planted conifers naturally. Evidently these areas would have to be managed by clear cuttings and planting at the end of each rotation.

In the light of the facts presented in this circular, it appears neither necessary nor desirable to resort to forest planting as a general restorative measure in the eastern hardwood forests. Natural replacement of the chestnut by other species, mostly possessing desirable qualities, is generally adequate. And on the vast areas involved, the expense of planting and of cleanings and liberation cuttings which are sure to be necessary, would in many cases impede and in others actually preclude artificial conversion. Natural reproduction, aided by such simple cutting methods as may be desirable, must be depended upon to rehabilitate the extensive areas of hardwood forests from which the chestnut has been killed. The artificial replanting of blight-killed chestnut stands with conifers, however, will doubtless prove desirable in isolated cases where small areas for one reason or another have been inadequately restocked with merchantable species.

ECONOMIC VALUE OF THE REPLACEMENT SPECIES

Chestnut was formerly the tree par excellence in the northeastern sprout-hardwood forests because of its abundance, rapid growth, ease of reproduction, tree form, and wood properties. It has a clear, straight stem with slight uniform taper, the tannin content of its bark and wood is relatively high, and the wood is resistant to decay. Because of these characteristics chestnut is well adapted for telegraph and telephone poles, railroad and mine ties, posts, tannic-acid wood, lumber, both for exterior and interior construction purposes, and fuel wood.

The best way of getting at the economic value of the replacement species is to consider their suitability for the purposes for which chestnut is used.

There are several species in the list of those found to be rehabilitating the blight-killed chestnut areas which are practically as well suited for exterior use as is chestnut. Chief among these are the oaks. White oak is generally classed as a very durable wood, and white ash, hickory, yellow poplar, and white pine as moderately durable. Also for such uses as ties and posts these species are of particular value. None of the species coming in on the chestnut-depleted areas will be able to take the place of the chestnut for telegraph and telephone poles. Its closest competitors are northern and southern white cedar (*Thuja occidentalis* and *Chamaecyparis thyoides*), southern yellow pine,[6] and Douglas fir (*Pseudotsuga taxifolia*).

Although for exterior lumber chestnut may be superior to some of the desirable species replacing it, chestnut does not excel these species as a wood for interior finish. The oaks, white ash, hickory, sweet birch, and others have fully as beautiful a figure and grain and will take as high a polish as the chestnut, though they are not so easily worked. Abundance and size are what give chestnut the advantage as a leading species in the production of hardwood lumber.

Chestnut has no outstanding characteristics as a fuel wood. With the exception of yellow poplar, cottonwood, and the aspens, all the replacement species surpass the chestnut in fuel value.

The use of tannin produced from chestnut wood is confined almost entirely to the production of heavy leathers, such as sole leather, belting, and harness. Approximately half the tanning material used in the production of heavy leather is chestnut wood extract. Chestnut wood grown in the southern part of the range of the species has approximately 10 to 11 per cent tannin content; wood grown in the North or at the higher altitudes contains about 7 to 8 per cent of tannin. The bark of various species of oak, containing 4 to 14 per cent of tannin, depending upon the species and season, has always held a prominent position as a source of high-grade tanning material. Tanning materials imported from many tropical countries are now competing with chestnut wood extract. The main advantage of chestnut over its competitors has been the abundant local supply. With the disappearance of the chestnut one of the chief sources of local supply of the tanning industry will be eliminated.

SUMMARY

This circular presents the more important results and conclusions of a study the objects of which were to determine the number and kinds of trees that naturally replace blight-killed chestnut and the means that might be used to replace the chestnut with desirable species. The study was begun in the earlier-infected chestnut stands of the Northeast where natural replacement is most advanced, and is being continued in the southern Appalachian region where the chestnut is now becoming heavily infected and is doomed to destruc-

[6] Composed chiefly of long-leaf pine (*Pinus palustris*), short-leaf pine (*Pinus echinata*), loblolly pine (*Pinus taeda*), and slash pine (*Pinus caribaea*).

tion by the blight. Many of the conclusions already reached apply in the South.

The most significant fact brought out is that the blight-killed chestnut has been largely replaced naturally by oak—red oak, white oak, chestnut oak, black oak, or scarlet oak. Such other valuable species as hickory, white ash, sugar maple, and sweet birch may be found associated with the oak. Although the stands are for the most part still depleted in the amount of growing stock or volume of wood, they are making satisfactory progress toward recovery.

The stand remaining after the death of the chestnut, composed chiefly of oaks, has responded to the increased light with accelerated growth ranging from 26 per cent in white oak to 63 per cent in red oak. The crowns of these trees are very effectively closing the smaller openings left by the chestnut. This increased growth rate, however, is smaller than was the growth rate of the chestnut.

Any cutting method that will increase the proportion of such valuable species as oak, white ash, and hickory in the new stand is to be encouraged. Stands running heavily to chestnut should be practically clear cut, seed trees of valuable species being left to restock the areas. Whenever feasible, the cutting of blighted chestnut should be deferred until it has died, as this tends to reduce the number of chestnut sprouts which would compete with the reproduction of other species.

Because the natural replacement of the chestnut, mostly by desirable species, is generally sufficient, and because the cost of planting, subsequent cleanings, and liberation cuttings is usually not justified, planting is not recommended as a general method of replacing the chestnut in the eastern hardwood forests.

LITERATURE CITED

(1) Anderson, P. J., and Rankin, W. H.
1914. endothia canker of chestnut. N. Y. Cornell Agr. Expt. Sta. Bul. 347, p. 530–618, illus.

(2) Barnes, L. C.
1917. utilization and reforesting of chestnut-blighted lands. Jour. Forestry 15: 854–858.

(3) Frothingham, E. H.
1924. some silvicultural aspects of the chestnut blight situation. Jour. Forestry 22: 861–872.

(4) Galloway, B. T.
1926. the search in foreign countries for blight-resistant chestnuts and related tree crops. U. S. Dept. Agr. Circ. 383, 16 p., illus.

(5) Gravatt, G. F.
1924. the present status of the chestnut blight. Jour. Forestry 22: 193–196, illus.

(6) ——— and Marshall, R. P.
1926. chestnut blight in the southern appalachians. U. S. Dept. Agr. Circ. 370, 11 p., illus.

(7) Hawley, R. C.
1920. guide to the maltby tract of the new haven water company. 17 p., New Haven, Conn.

(8) Illick, J. S.
1921. replacement of the chestnut. Jour. Forestry 19: 105–114.

(9) Korstian, C. F.
1915. pathogenicity of the chestnut bark disease. Nebr. Univ., Forest Club Ann. 6: 45–66, illus.

(10) KORSTIAN, C. F.
1924. THE TRAGEDY OF CHESTNUT; HOW AN UNCONTROLLABLE PEST IS EXTERMINATING A VALUABLE HARDWOOD SPECIES. South. Lumberman 117 (1525): 180–183, illus.
(11) MATTOON, W. R.
1909. THE ORIGIN AND EARLY DEVELOPMENT OF CHESTNUT SPROUTS. Forestry Quart. 7: 34–47, illus.
(12) NELLIS, J. C.
1914. USES FOR CHESTNUT TIMBER KILLED BY THE BARK DISEASE. U. S. Dept. Agr. Farmers' Bul. 582, 24 p., illus.
(13) [PENNSYLVANIA CHESTNUT TREE BLIGHT COMMISSION.]
1915. THE PUBLICATIONS OF THE PENNSYLVANIA CHESTNUT TREE BLIGHT COMMISSION, 1911–1913. [663] p., illus. Harrisburg, Pa.
(14) PERRY, G. S.
1922. THE SPECIAL PLANTING PROBLEMS IN PENNSYLVANIA. Jour. Forestry 20: 507–512.
(15) RICHARDS, E. C. M.
1914. REFORESTING CUT-OVER CHESTNUT LANDS. Forestry Quart. 12: 204–210.
(16) ———
1917. A STUDY OF REFORESTED CHESTNUT CUT-OVER LAND. Jour. Forestry 15: 609–614.
(17) SCHLICH, W.
1910. SCHLICH'S MANUAL OF FORESTRY. Ed. 4, rev., v. 2, illus. London.
(18) SHEAR, C. L., STEVENS, N. E., and TILLER, R. J.
1917. ENDOTHIA PARASITICA AND RELATED SPECIES. U. S. Dept. Agr. Bul. 380, 82 p., illus.
(19) TOUMEY, J. W.
1914. WHAT SHOULD BE DONE WITH THE CHESTNUT STANDS IN SOUTHERN NEW ENGLAND. Soc. Amer. Foresters Proc. 9: 38–43.
(20) ZIEGLER, E. A.
1920. PROBLEMS ARISING FROM THE LOSS OF OUR CHESTNUT. Forest Leaves 17: 153–155.
(21) ZON, R.
1904. CHESTNUT IN SOUTHERN MARYLAND. U. S. Dept. Agr., Bur. Forestry Bul. 53, 31 p., illus.

ADDITIONAL COPIES
OF THIS PUBLICATION MAY BE PROCURED FROM
THE SUPERINTENDENT OF DOCUMENTS
GOVERNMENT PRINTING OFFICE
WASHINGTON, D. C.
AT
5 CENTS PER COPY
▽